The Mars Odyssey Navigation Experience

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Extended Abstract

The 2001 Mars Odyssey Mission has returned an Orbiter to Mars to map the planet and search for water. The success of this mission has re-established confidence in Mars exploration that will pave the way for future orbiters, landers, and rovers. Now that the spacecraft has completed its journey to Mars, it is poised to collect a rich science harvest during the primary orbital mission that will begin in February 2002 and continue until at least 2005. This paper will present an overview of the Navigation performance, with a comparison of the pre-launch requirements and expected performance to the in-flight experience.

Odyssey launched atop a Boeing Delta II 7925 from Cape Canaveral on April 07, 2001. A twenty-one day launch period was designed to provide two launch opportunities on each day. The launch targets were designed to inject the spacecraft on the desired interplanetary trajectory to Mars, and also to accommodate planetary quarantine and propellant budget requirements. Launch occurred on the first opportunity and the launch vehicle performance was excellent, placing the spacecraft on the desired trajectory to Mars.

The 200-day journey to Mars was filled with spacecraft checkout and calibration activities, as well as four trajectory correction maneuvers. This cruise phase of the mission was the most challenging from a trajectory determination perspective, as the driving navigation requirement was to deliver the spacecraft to an altitude 300 km above the North pole of Mars. The performance easily met the requirement, as the achieved altitude at encounter was less than one kilometer from the target altitude.

The Mars Orbit Insertion (MOI) maneuver was the only use of the bi-propellant propulsion system on the spacecraft. MOI slowed the velocity of the spacecraft by 1144 m/s to allow the spacecraft to be captured into orbit around the planet. MOI executed successfully on October 23, 2001, placing the spacecraft into an 18.6-hour orbit about Mars.

The aerobraking phase of the mission was designed to lower the orbit period from the 18.6-hour capture orbit to the desired 2-hour mapping orbit. This was accomplished by flying through the upper atmosphere of the planet and allowing the atmospheric drag to remove energy from the orbit. This was the most demanding operational phase of the mission which required 24-hour, seven days-per-week monitoring to ensure spacecraft health and safety. The spacecraft flew through the atmosphere on every orbit, putting the spacecraft at risk with each "drag-pass". The primary requirement on the Navigation team was to provide a trajectory that would predict the time of the upcoming drag-passes to within 225 seconds. As the density profile experienced during each drag-pass was highly variable, the amount of energy removed with each drag pass, and therefore the change in orbit period, was difficult to predict to high accuracy. Trajectory updates were delivered up to four times per day to accommodate the uncertain atmosphere and meet the strict timing requirement. Odyssey successfully finished aerobraking on January 11, 2002, after 330 drag-passes through the Martian atmosphere.

Aerobraking effectively reduced the orbit period as planned, but additional propulsive maneuvers were required to change the shape of the orbit, and fix Odyssey into its final mapping orbit. Five

maneuvers were executed in the three weeks following aerobraking to achieve the desired mapping orbit, and "freeze" it. The last if these maneuvers was executed on January 30, 2002.

Odyssey began its science mission on February 19, 2002 and will continue its primary mission to map the planet until early 2005. During this phase, the Navigation task is to provide high-accuracy trajectory predicts and reconstructions for science planning and processing. To meet the strict position and pointing requirements of the high-resolution camera, trajectory predicts are delivered twice per week.

The Mars Odyssey mission is managed at JPL under the auspices of the Mars Exploration Directorate. The spacecraft flight elements were built and are managed by Lockheed-Martin Astronautics in Denver, Colorado. The science instruments were built and are managed by their respective institutions.

Odyssey Mission Schematic